Cameron, Missouri
Water Supply Study
Grindstone Reservoir and Three City Lakes

Cameron has a system of four lakes. The older three lakes have met their Original needs. Lake #1 and lake #2 are small lakes above lake #3 and are used primarily for sediment control. Lake #1 has approximately 110 Acre Feet of storage, Lake #2 has 310 Acre Feet and lake #3 has 950 acre feet of total storage. In addition, the Grindstone Reservoir was completed in 1992 and contains 1300 acre feet of municipal storage. Lakes #1 and #2 are used for water supply only in emergencies.

Water usage by the city of Cameron has been increasing each year. Following is the annual volume of water used:

1998	505.23 Million Gallon
1999	508.34 Million Gallon
2000	540.89 Million Gallon
2001	540.74 Million Gallon
2002	556.09 Million Gallon

Demand for this study was 1.5 million gallon per day.
Optimized demand was determined to be about 1.5 million gallon per day.

Operation of the system is for using water from Lake #3 to the treatment plant. Lake #3 inflow is runoff from the uncontrolled drainage area above lake #3 and spillage from lakes #1 and #2 as well as pumping from Grindstone Reservoir. Water in Lake #3 is then pumped into the treatment plant.

Cameron's system of lakes was analyzed using the NRCS's computer program named "RESOP". Following is the data and procedures for input to the program.

STO-AREA Elevation-Storage and Elevation-Area data were determined from the as built plans for the Grindstone Reservoir and a 1996 sediment survey of lakes #1 through #3.

Grindstone Reservoir
Constructed in 1991
Contains 569 Acre Feet of sediment storage + 1300 Acre Feet Water supply storage.

Elevation Feet	Surface Area Acres	Storage Ac.Ft.
885	75	300
890	111	850
895	156	1500
900	208	2400
905	265	3550
910	336	4950
915	415	6750
920	504	9000
925	620	12000
930	750	15300

Reservoir no. 1

Elevation Feet	Area Acres	Storage Acre Feet
925	0	0
926	0.02	0.01
928	2.03	2.06
930	4.29	8.38
932	6.77	19.44
934	9.37	35.58
936	12.02	56.97
938	14.66	83.65
940	17.04	115.35
Weir elevation =		939.75

Reservoir no. 2

Elevation Feet	Area Acres	Storage Acre Feet
917	0	0
918	0.1	0.05
920	0.44	0.59
922	1.18	2.21
924	2.27	5.66
926	4.15	12.08
928	6.05	22.28
930	8.56	36.89
932	11.16	56.61
934	13.73	81.50
936	16.59	111.82
938	20.31	148.72
940	22.64	191.67
942	25.27	239.58
944	28.58	293.43

Weir elevation = 945.2

Reservoir no. 3

Elevation Feet	Area Acres	Storage Acre Feet
887	0	0
888	0.24	0.12
890	1.75	2.11
892	4.89	8.75
894	12.56	26.20
896	19.03	57.79
898	24.55	101.37
900	31.06	156.98
902	41.53	229.57
904	54.92	326.02
906	66.19	447.13
908	73.52	586.84
910	80.20	740.56
912	88.10	908.86

Weir elevation = 912.5

LIMITS Grindstone Reservoir

Maximum Pool storage = 1869 Ac.Ft. (569 Ac.Ft. sediment and 1300 acre feet municipal water supply storage).
Minimum Pool storage 569 Ac.Ft.

Starting storage was considered at maximum pool.

The Drainage area of the lake is 13,382 acres (20.91 Sq. Mi.).

Lake #1

Maximum pool storage = 110 Acre Feet at elevation 939.75 feet.
Minimum Pool storage = 2 Acre Feet at elevation 928 feet.

Starting storage was considered at maximum pool.

The drainage area = 1056 Acres (1.65 Square Miles)

Lake #2

Maximum pool storage = 310 Acre Feet at elevation 945.2 feet.
Minimum Pool storage = 6 Acre Feet at elevation 924 feet.

Starting storage was considered at maximum pool.

The drainage area = 1152 Acres (1.80 Square Miles)

Lake #3

Maximum pool storage = 950 Acre Feet at elevation 912.5 feet.
Minimum Pool storage = 100 Acre Feet at elevation 898.0 feet.

Starting storage was considered at maximum pool.

The drainage area = 1106 Acres (1.73 Square Miles)
Total drainage area including #1 and #2 is 3314 acres.
(5.18 Square Miles)

GENERAL The adjustment to convert from pan evaporation to lake evaporation was made before entering evaporation data. The factor was 0.76. As a result a factor of 100.0 was used here.

The record period of drought is in the 1950's.
Analysis began in January 1951 and ended December 1959

SEEPAGE The reservoir seepage varied for each lake. For the GLM lake seepage varied from 0 seepage near empty to a maximum of 1.1 inch per month when at full pool. This lake was built using controlled construction procedures with the core of the dam being clay material so that the dam would be impermeable. Lakes #1, #2 and #3 have less static pressure because the water is not as deep against the dam but were built under less controlled conditions. The material in each dam is compacted earth of clayey soils. These lakes are shallow so that static pressure is low, as a result seepage was lower for smaller depths. Lake #3 values varied from 1.0 inches per month to near 0 inches when the pool was low. Lakes #1 and #2 would have very little seepage for RESOP runs because any seepage through the dam would drain into lake #3.

RAINFALL There were no rainfall records for the Cameron area until 1998. Records from Hamilton were available and used for the period June 1954 through 1959. Prior to that date(1951 through 1954) the Rainfall data at Gallatin, Mo. was used. Gallatin is located 14 miles north of Hamilton. Rainfall data came from the Gallatin, Mo. rain gage for the period 1951 through May 1954.

RUNOFF This is the runoff into the lake from its drainage area. Monthly runoff volumes in watershed inches. Three gage runoff data were examined, one at Jenkins Branch, a tributary to Platte River. Crooked river at Richmond with a drainage area of 159 square miles and the other gage was on East Fork Big Creek at Bethany having a drainage area of 95 square miles. East Fork Big Creek Gage data best fit the rainfall data. As a result it was selected to represent the runoff from the watersheds for the period 1951 through 1959. Monthly runoff was compared to the rainfall and if the results did not appear reasonable, adjustments were made for that month by looking at individual rains and estimating antecedent moisture then adjusting runoff based on NRCS's runoff curve numbers.

EVAP. Pan evaporation at the Lakeside gaging station was used as a base because it has data for year around evaporation. This data was updated with gage data from stations at Spickard, New Franklin, and Columbia. Depending on the latest data for the station nearest to Cameron. The adjustment factor of 0.76 to convert from pan to lake evaporation was applied at this step.

DEMAND This was determined by city records. Cameron's 2002 water use was approximately 1.5 million gallons per Day.

OTHER This refers to the volume of water that entered the system from other sources.

The Grindstone Reservoir had no other inflows beyond rainfall and runoff.
Lakes #1 and #2 had no other inflows.

Lake #3 received spillage from #1 and #2 as well as pumped inflow from the GLM lake. To simplify the input to the program, lake #2 spillage was treated as upper site inflow and Lake #1 spillage plus the Grindstone Reservoir demand were added together and entered as OTHER.

Cameron, Missouri

Water Supply Study
Grindstone Reservoir
Storage Volume

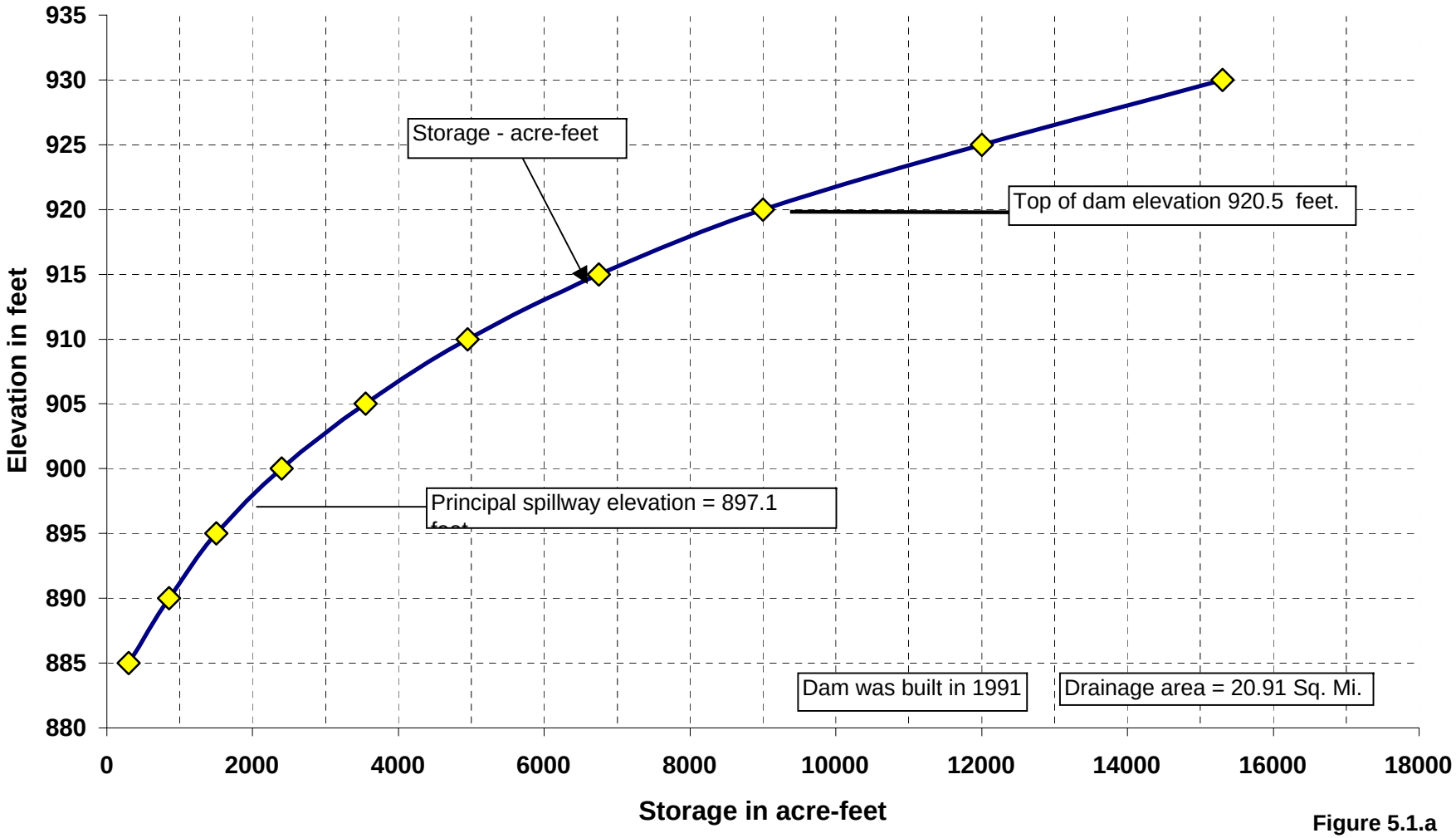


Figure 5.1.a

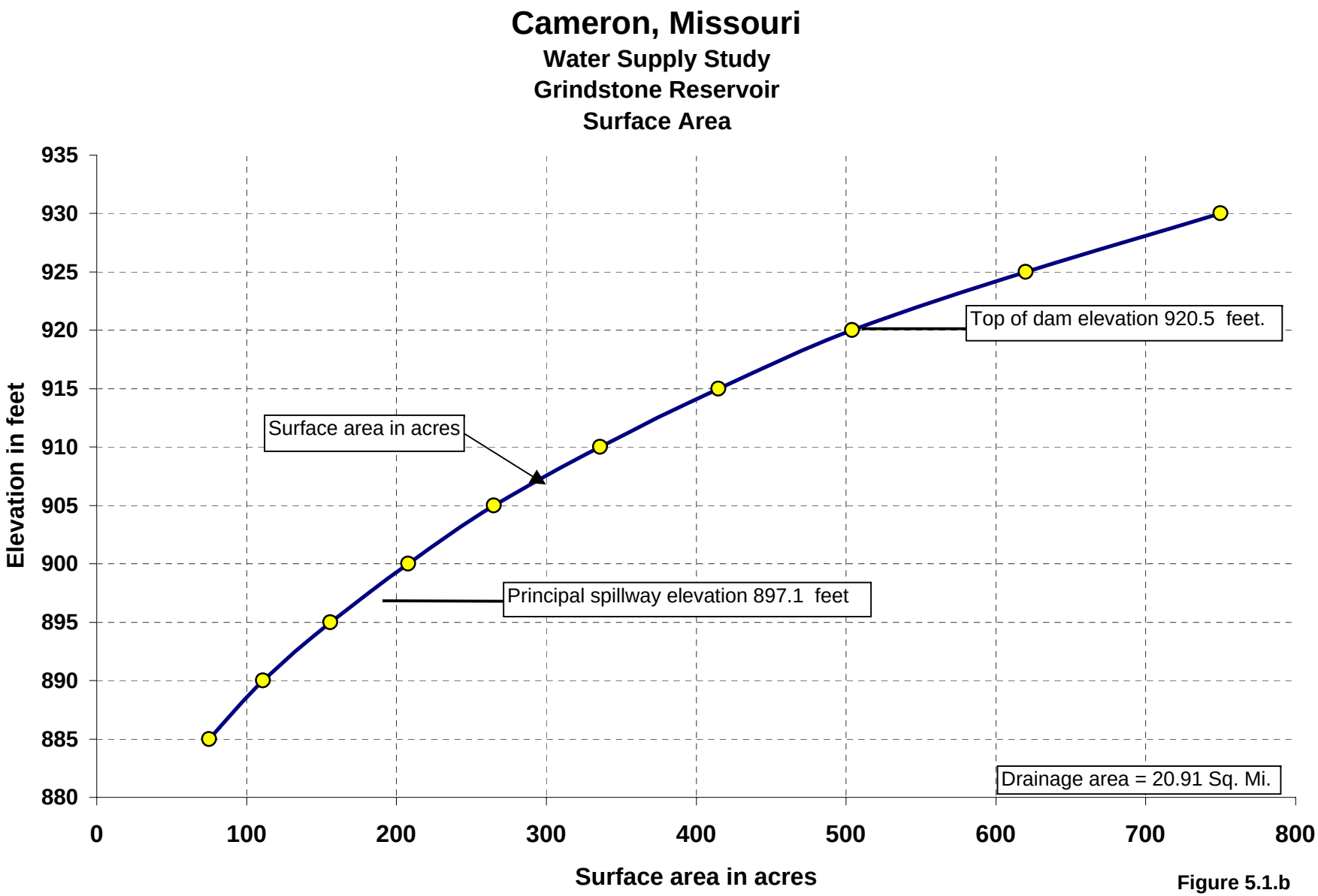

Cameron, Missouri
Water Supply Study
Grindstone Reservoir
Surface Area
Elevation in feet
935
930
925
920
915
910
905
900
895
890
885
880
0
100
200
300
400
500
600
700
800
Surface area in acres
Surface area in acres
Top of dam elevation 920.5 feet.
Principal spillway elevation 897.1 feet
Drainage area = 20.91 Sq. Mi.

Figure 5.1.b

Cameron, Missouri

Water Supply Study

Reservoir No. 1

Storage Volume

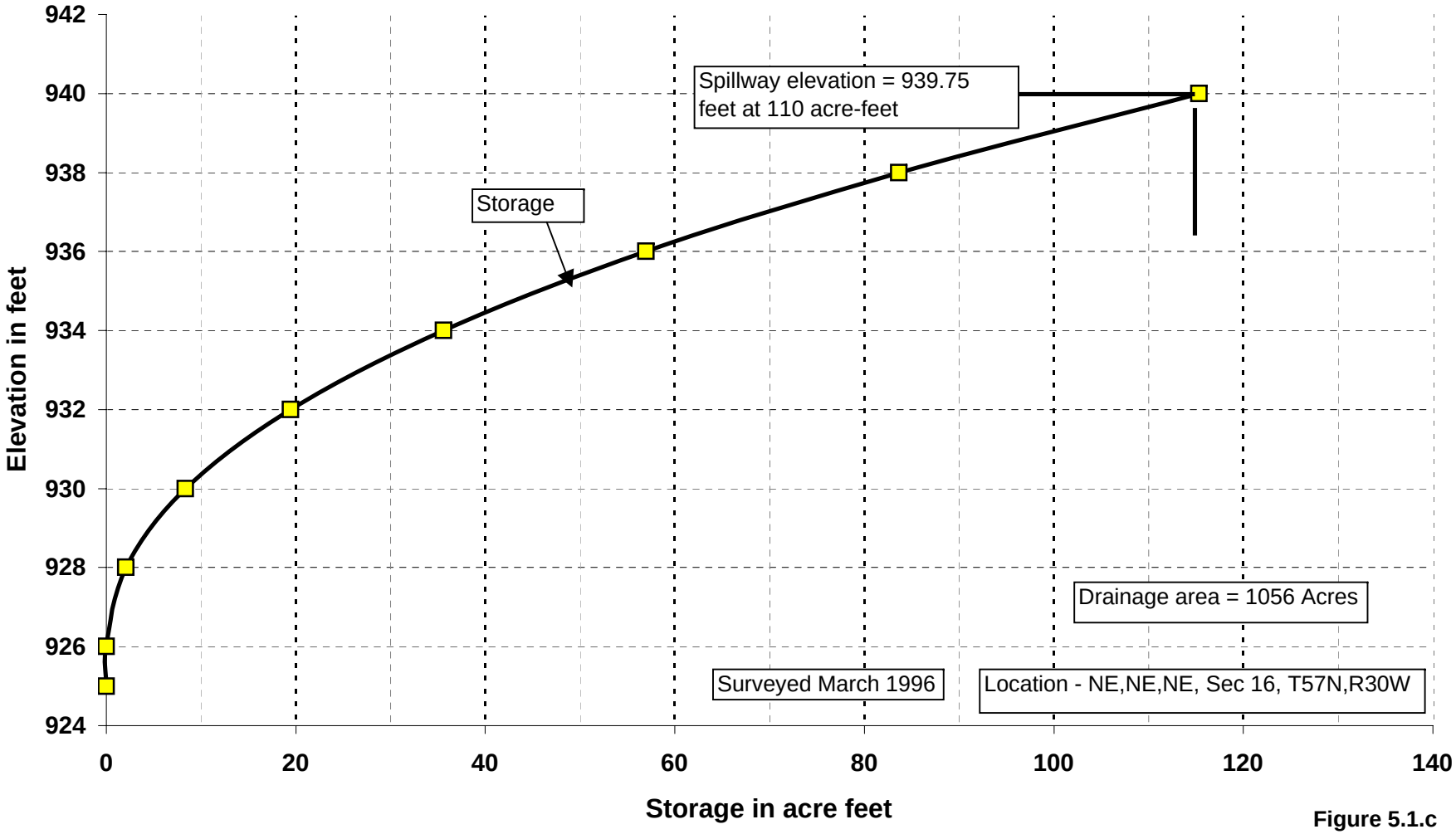


Figure 5.1.c

Cameron, Missouri

Water Supply Study
Reservoir No. 1
Surface Area

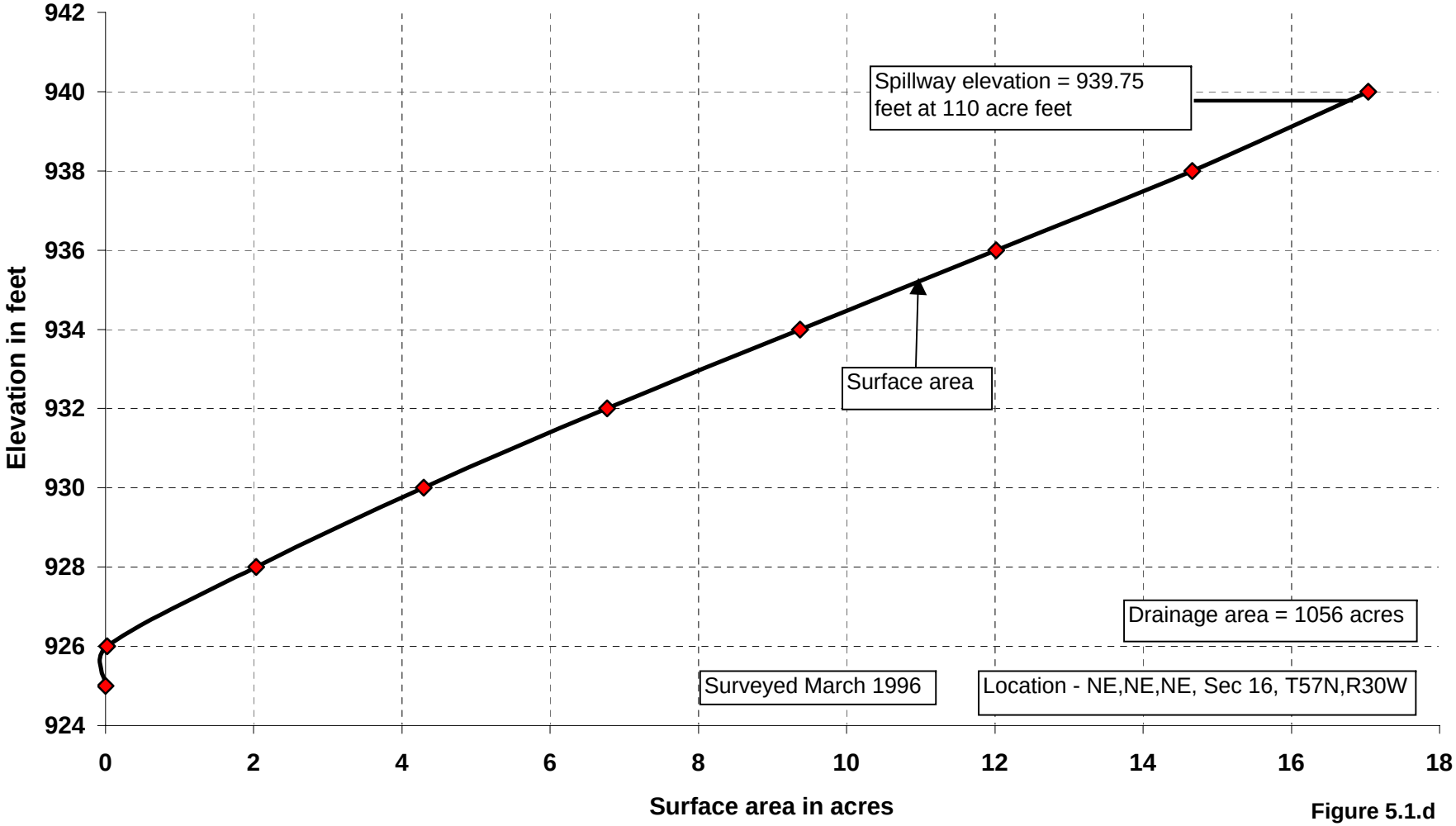


Figure 5.1.d

Cameron, Missouri

Water Supply Study

Reservoir No. 2

Storage Volume

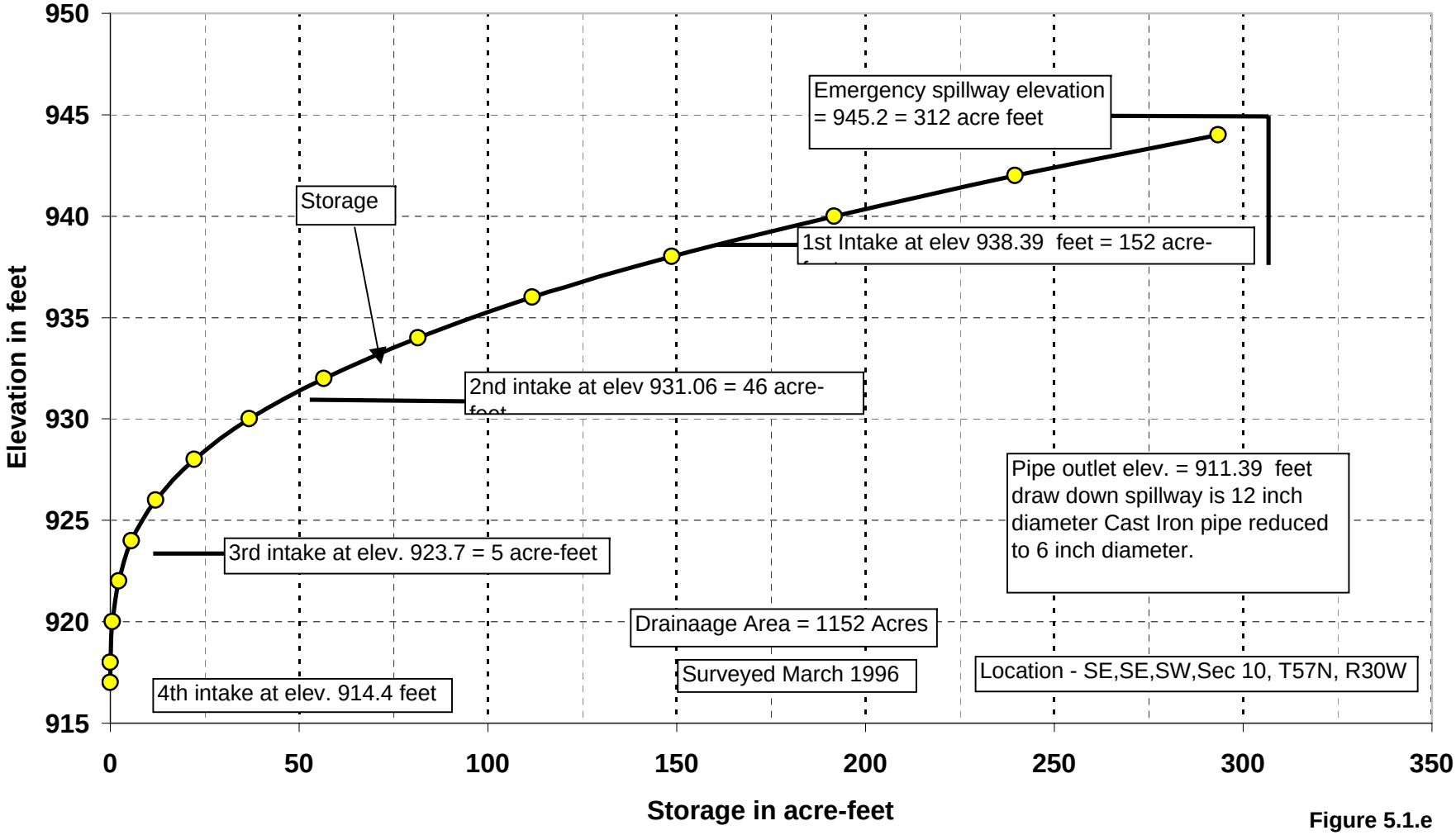


Figure 5.1.e

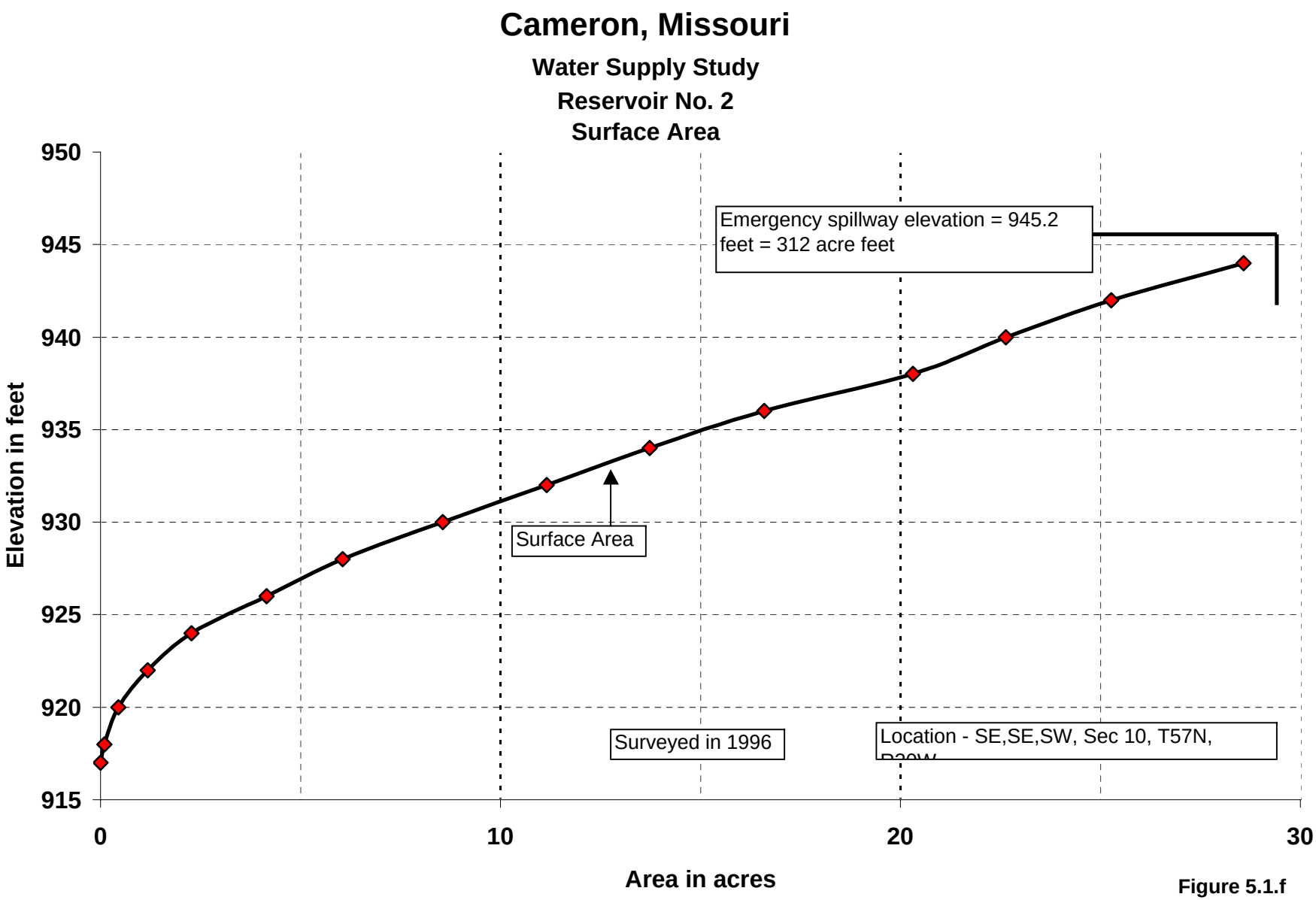

Cameron, Missouri
Water Supply Study
Reservoir No. 2
Surface Area
Elevation in feet
950
945
940
935
930
925
920
915
0
10
20
30
Area in acres
Emergency spillway elevation = 945.2 feet = 312 acre feet
Surface Area
Surveyed in 1996
Location - SE,SE,SW, Sec 10, T57N,

Figure 5.1.f

Cameron, Missouri

Water Supply Study

Reservoir No. 3

Storage Volume

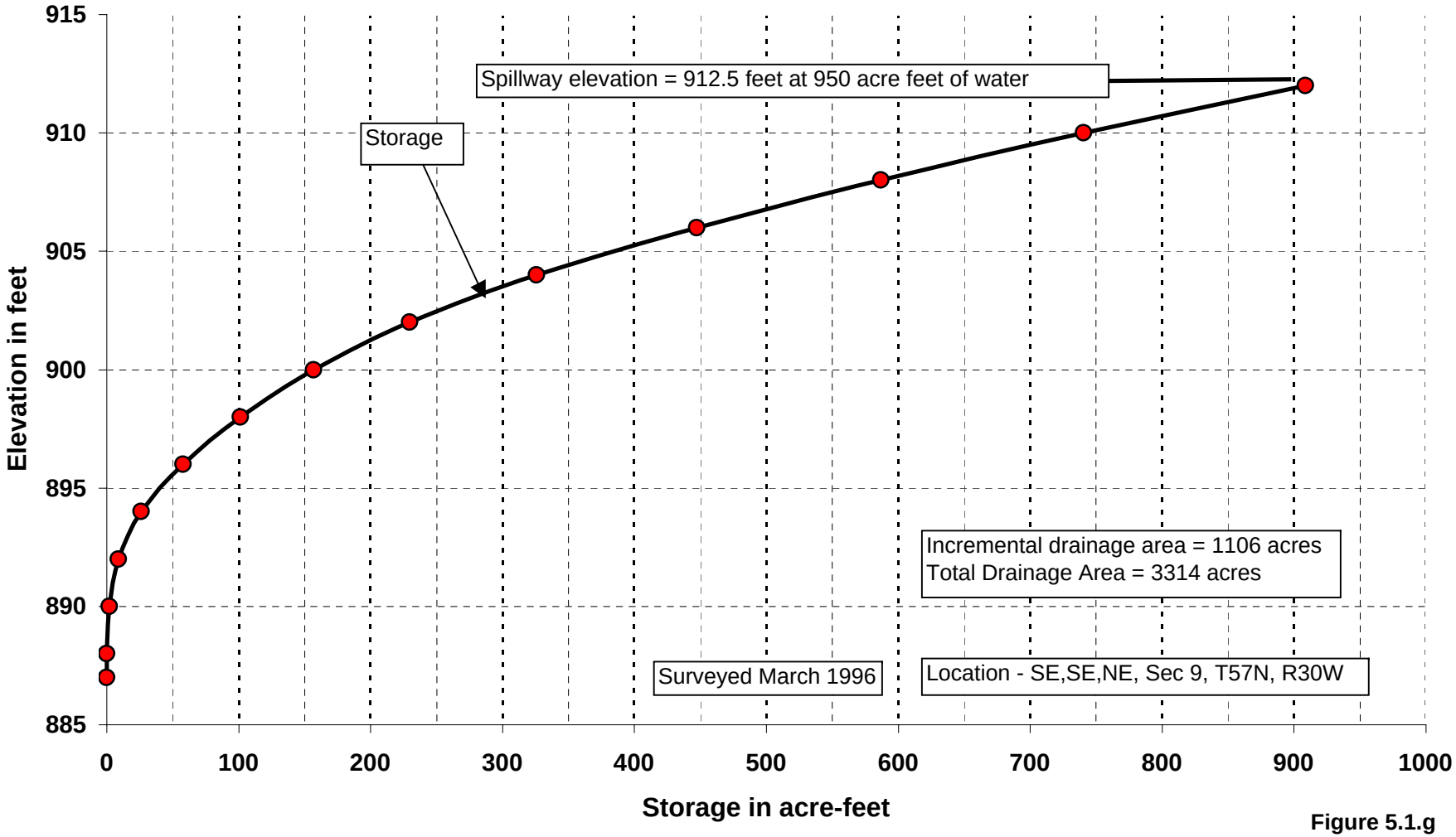


Figure 5.1.g

Cameron, Missouri

Water Supply Study

Reservoir No. 3

Surface Area

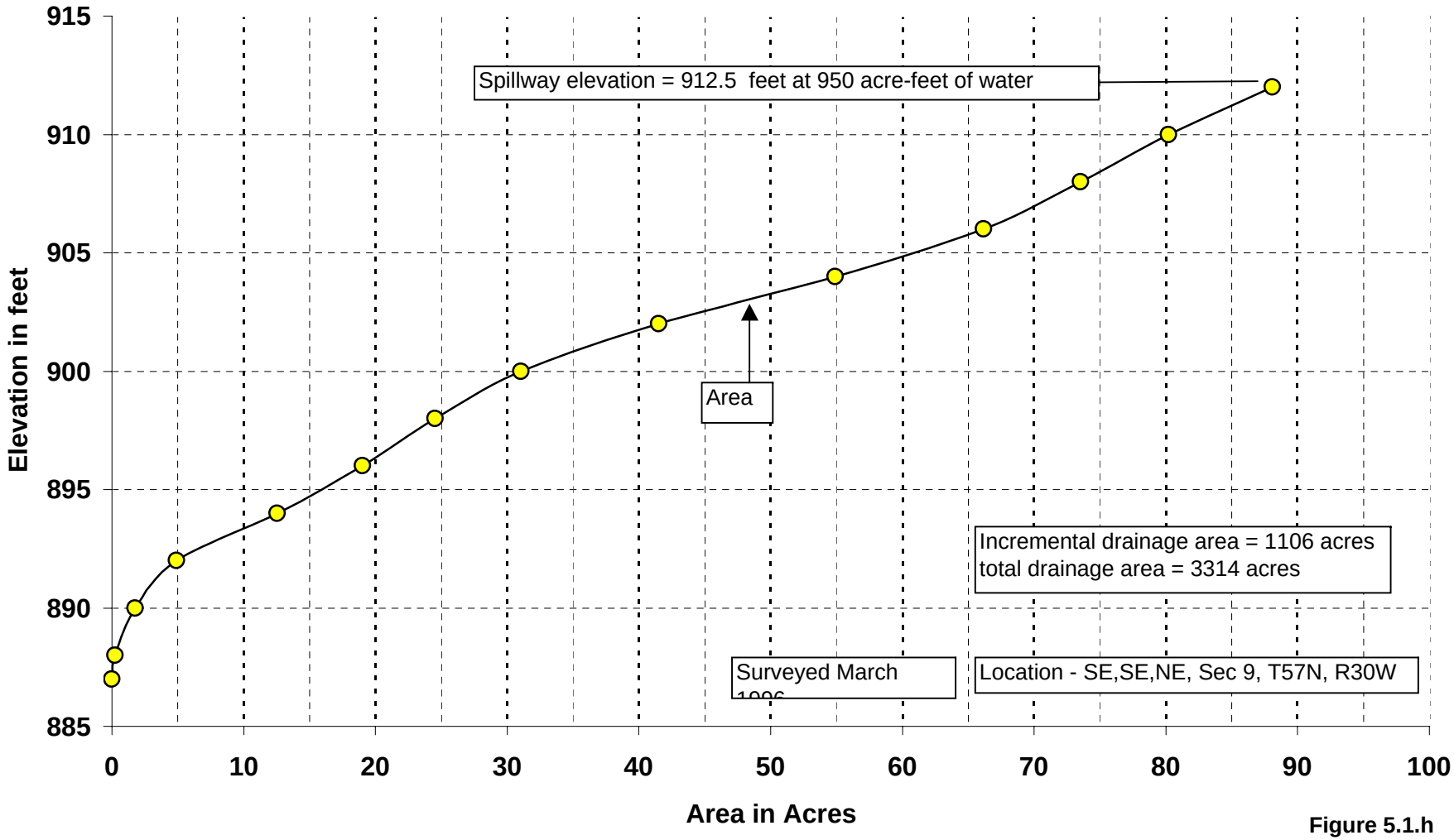


Figure 5.1.h

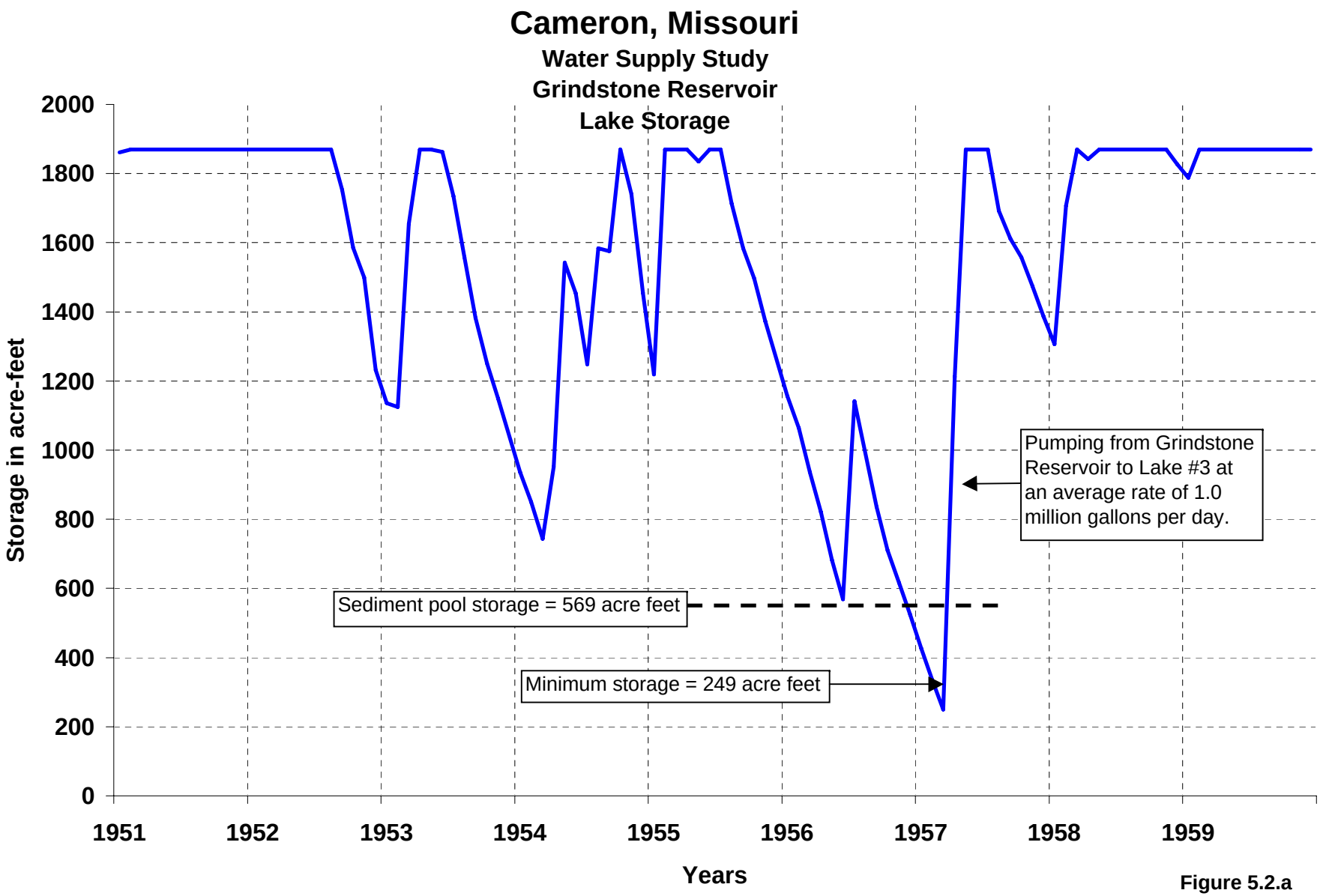

Cameron, Missouri
Water Supply Study
Grindstone Reservoir
Lake Storage
Storage in acre-feet
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Years
Pumping from Grindstone Reservoir to Lake #3 at an average rate of 1.0 million gallons per day.
Sediment pool storage = 569 acre feet
Minimum storage = 249 acre feet

Figure 5.2.a

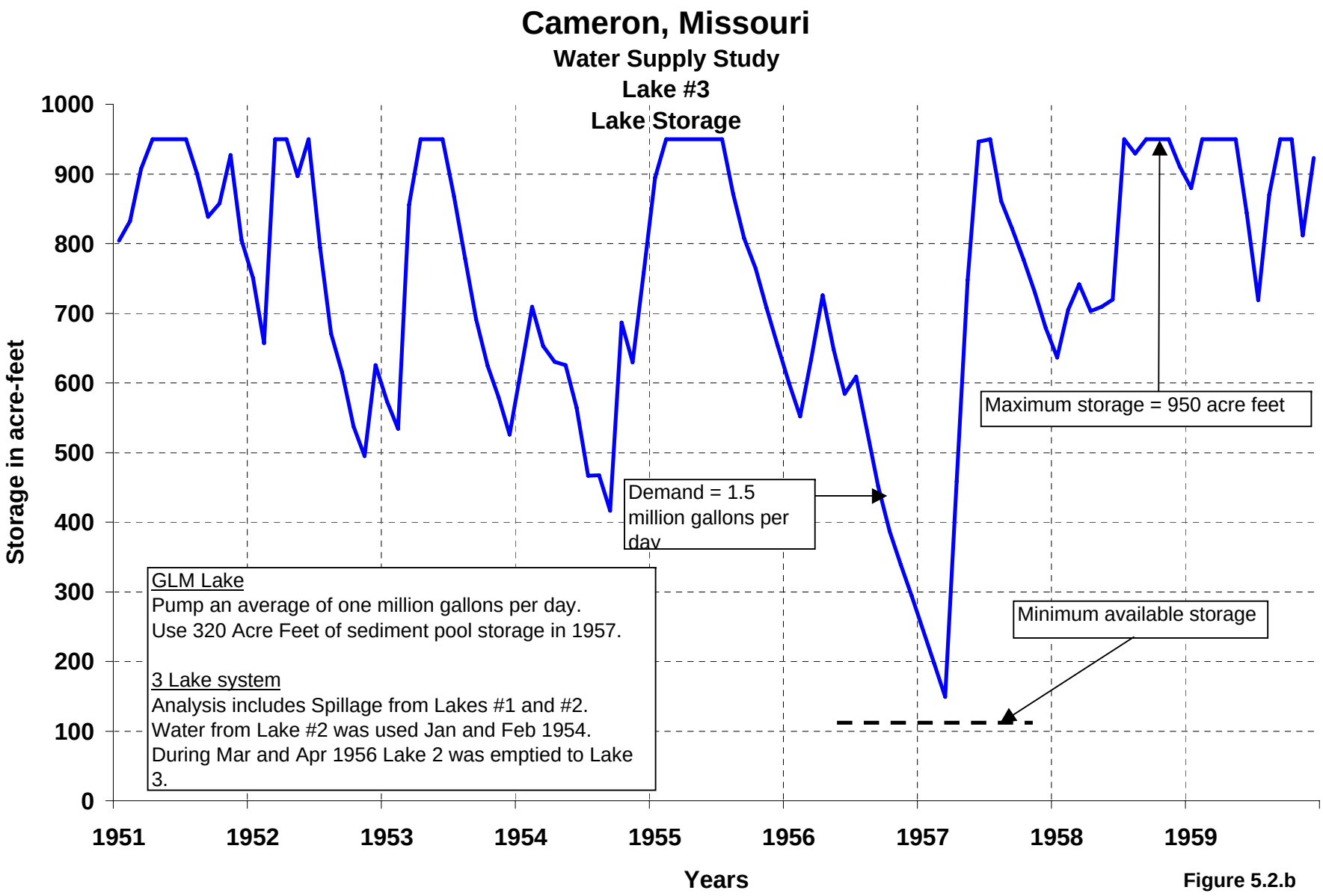

Cameron, Missouri
Water Supply Study
Lake #3
Lake Storage
Storage in acre-feet
1000
900
800
700
600
500
400
300
200
100
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Years
Maximum storage = 950 acre feet
Demand = 1.5 million gallons per day
Minimum available storage
GLM Lake
Pump an average of one million gallons per day.
Use 320 Acre Feet of sediment pool storage in 1957.
3 Lake system
Analysis includes Spillage from Lakes #1 and #2.
Water from Lake #2 was used Jan and Feb 1954.
During Mar and Apr 1956 Lake 2 was emptied to Lake 3.

Figure 5.2.b

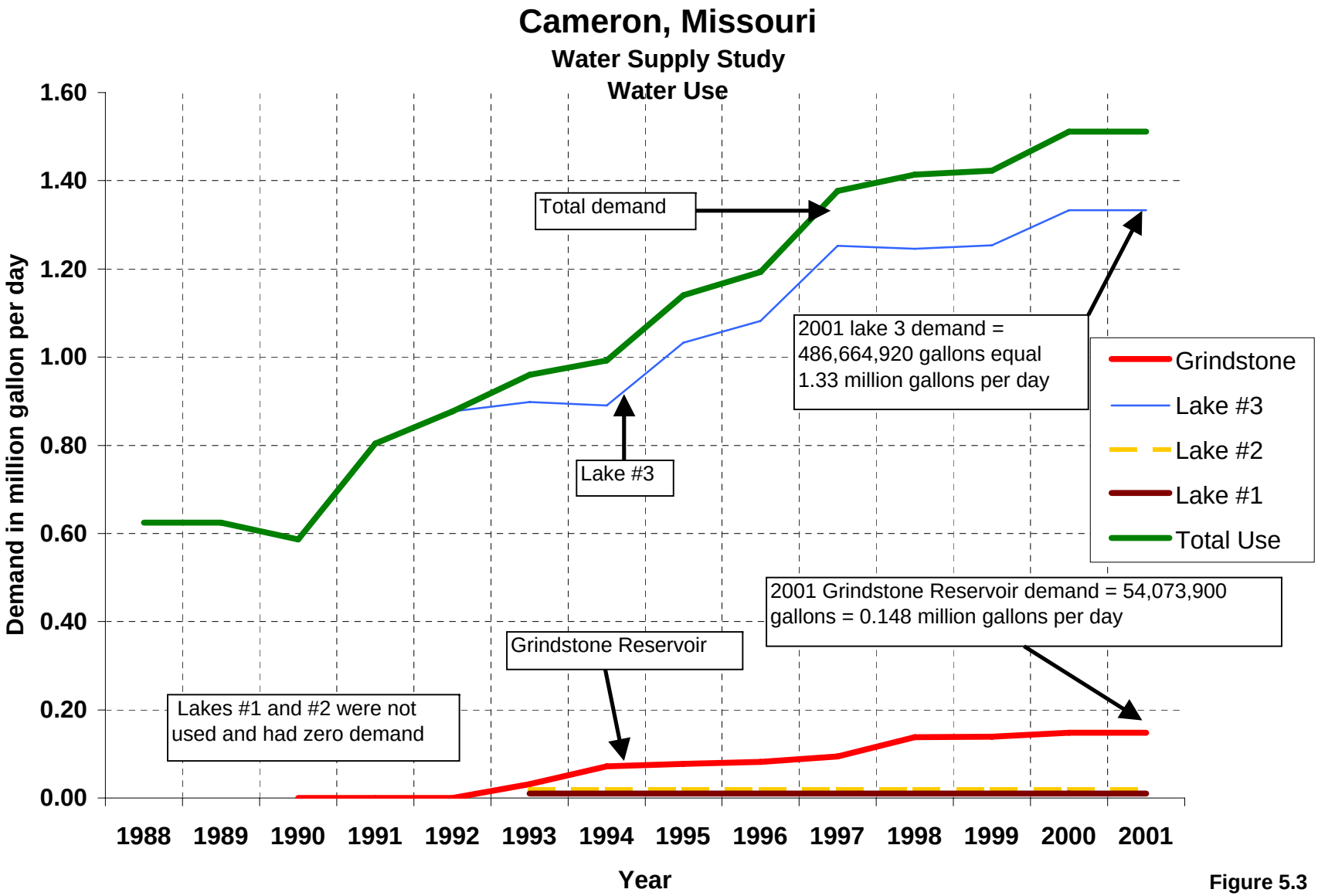
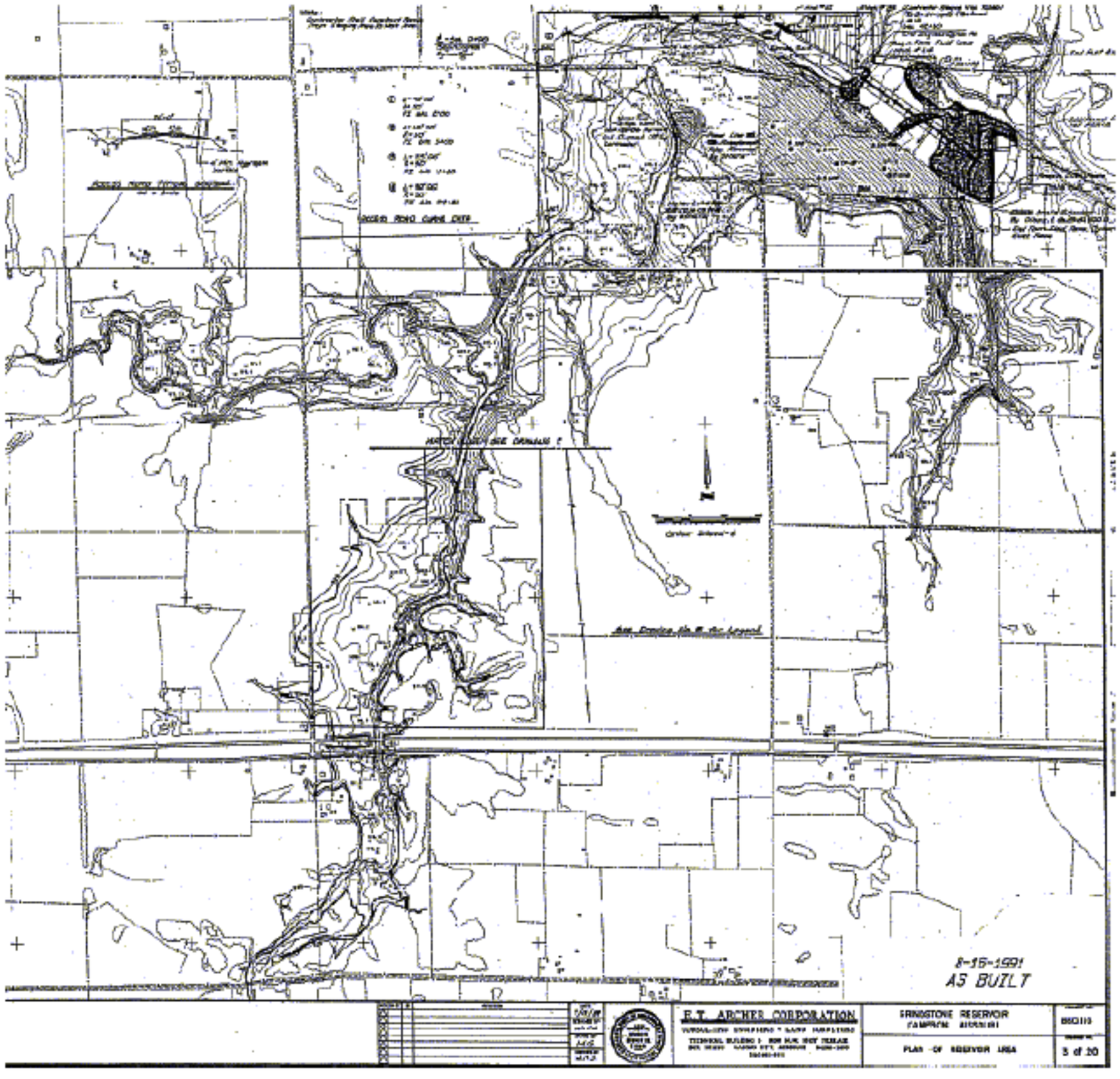
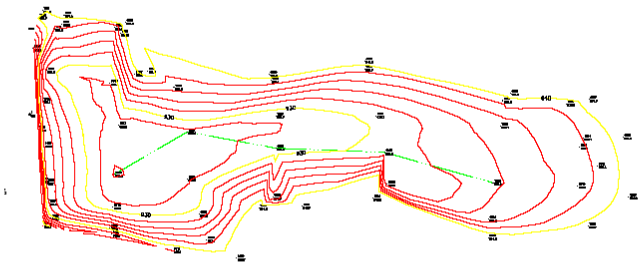

Cameron, Missouri
Water Supply Study
Water Use
Demand in million gallon per day
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Year
Total demand
2001 lake 3 demand = 486,664,920 gallons equal 1.33 million gallons per day
Lake #3
Grindstone
Lake #3
Lake #2
Lake #1
Total Use
2001 Grindstone Reservoir demand = 54,073,900 gallons = 0.148 million gallons per day
Grindstone Reservoir
Lakes #1 and #2 were not used and had zero demand

Figure 5.3

GLM - A2 Lake


8-16-1991
AS BUILT
E.T. ARCHER CORPORATION
ERINGSTONE RESERVOIR
PLAN OF RESERVOIR AREA
5 of 20

Title: SCSBD-G.DWG



Cameron Reservoir #1 Weir Elev. 939.75

Elev.	Sq. Ft.	Acres
926	730.5	0.02
928	88,776.9	2.03
930	187,062.5	4.29
932	295,237.3	6.77
934	408,061.8	9.37
936	523,576.6	12.02
938	638,752.2	14.66
940	742,055.9	17.04

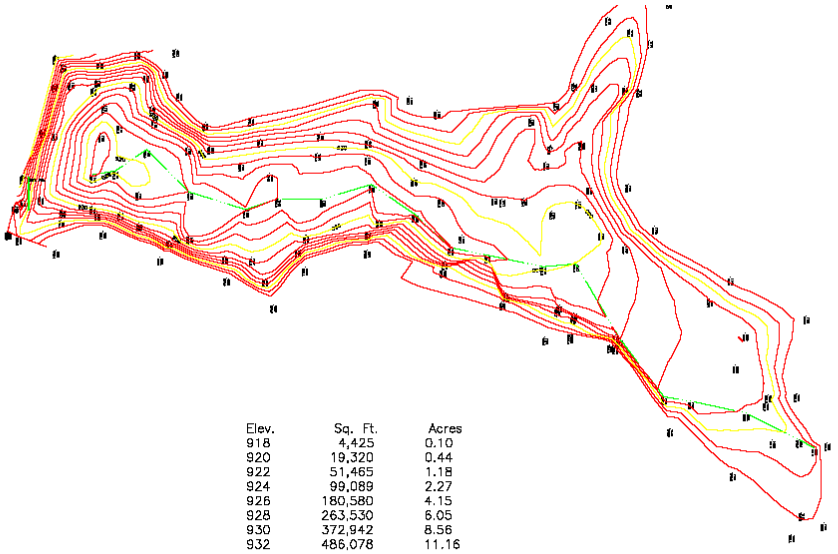
100 50 0 100 200
Scale in Feet

Figure 5.4.b Bathymetric map and area/volume table of Cameron #1, Missouri

Date
Approved by
Title
Date
Designed
Drawn
Traced
Checked
City of Cameron Reservoir No. 1
Cameron, Missouri
U.S. DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE
CAD FILE NO.
DRAWING NO.
SHEET NO. OF

Title: SCSBD-G.DWG

Figure 5.4.c Bathymetric map and area/volume table of Cameron #2, Missouri



Elev.	Sq. Ft.	Acres
918	4,425	0.10
920	19,320	0.44
922	51,465	1.18
924	99,089	2.27
926	180,580	4.15
928	263,530	6.05
930	372,942	8.56
932	486,078	11.16
934	598,143	13.73
936	722,805	16.59
938	884,905	20.31
940	986,295	22.64
942	1,100,682	25.27
944	1,245,012	28.58

City of Cameron Reservoir No. 2
Cameron, Missouri

U.S. DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE

CAD FILE NO.

DRAWING NO.

SHEET NO. 2 OF 4

Title: SCSBD–G.DWG

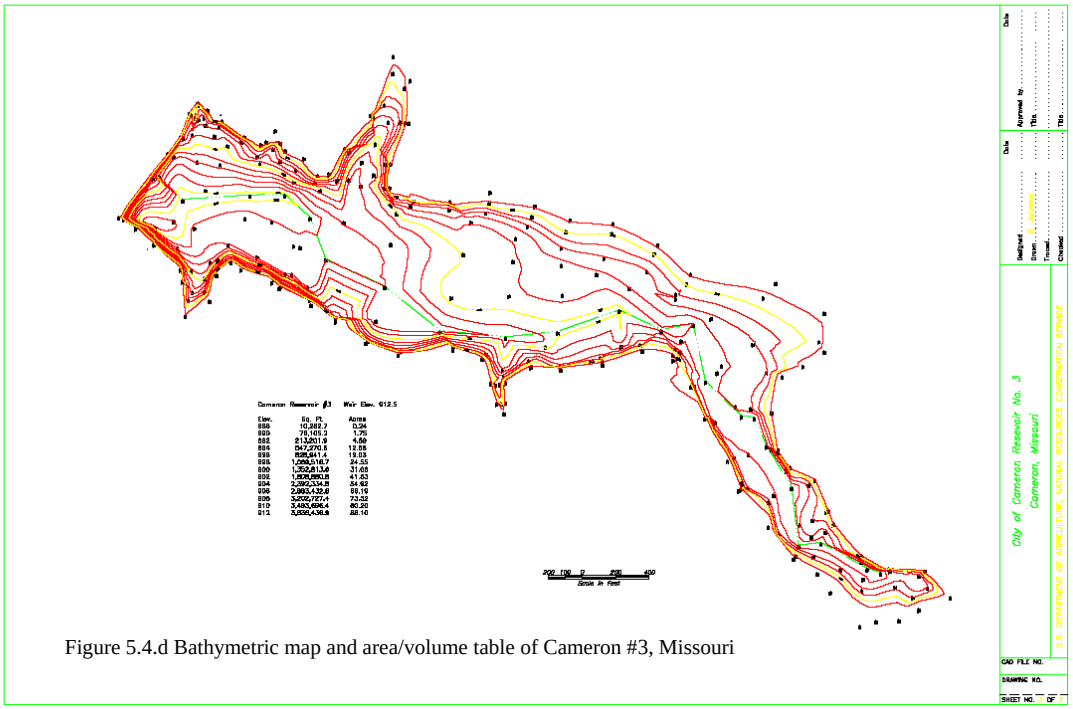


Figure 5.4.d Bathymetric map and area/volume table of Cameron #3, Missouri